Electrophoretic deposition of cobalt ferrite and platinum cobalt nanoparticles as electrocatalysts

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The development of an advanced thermo-chemical process based on a Sulfur Ammonia (SA) cycle for splitting water to produce hydrogen with solar energy is ongoing [1]. The hydrogen production step consists of electrolytic oxidation of ammonium sulfite to ammonium sulfate in an aqueous solution. The anodic reaction is kinetically slow, so improvements in the electrocatalysts are being sought.

In this study, electrophoretic deposition (EPD) of two possible anode electrocatalysts, nanoparticles of cobalt ferrite ($CoFe_2O_4$) and platinum cobalt (Pt_3Co), have been investigated. Cobalt ferrite particles of ~20 nm were synthesized by the procedure of Zi et al. [2]. The ~60 nm size particles of Pt_3Co on carbon (~70%) were purchased from Sigma Aldrich.

The EPD bath used was a suspension of 2 mg/mL nanoparticles in 90 vol. % water and 10 vol. % isopropanol with 0.4 g/L hexadecyltri-methylammonium bromide (CTAB). Both aluminum foil and graphite paper substrates ranging from 1 cm^2 to 5 cm^2 were used. The EPD was performed at a constant current for a set duration to give a thin and uniform coating.

Figure 1 shows deposit density vs time for cobalt ferrite nanoparticles deposited onto aluminum foil at 30 mA. The deposit density increased linearly with time. Figure 2 shows the deposit density vs time for platinum cobalt nanoparticles onto aluminum foil at 32 mA for deposit time only up to 1 min, which also increased linearly, but with non-zero intercept. Also, deposit density is much smaller for the platinum cobalt than the cobalt ferrite for the same deposition time.

EPD was used to deposit the nanoparticles onto graphite paper using the same procedure. These deposits were tested for electrocatalytic activity using linear sweep voltammetry in a standard three-electrode cell with a graphite counter electrode and SCE reference electrode. The voltage was swept from -0.25 to 1.0 V vs SCE in a 2M ammonia sulfite electrolyte, as shown in Figure 3. The deposit density of the cobalt ferrite particles was 0.81 g/cm^2, and the deposit density for the platinum cobalt particles was 0.60 g/cm^2. Figure 3 shows that both cobalt ferrite and platinum cobalt nanoparticles are electrocatalytic.

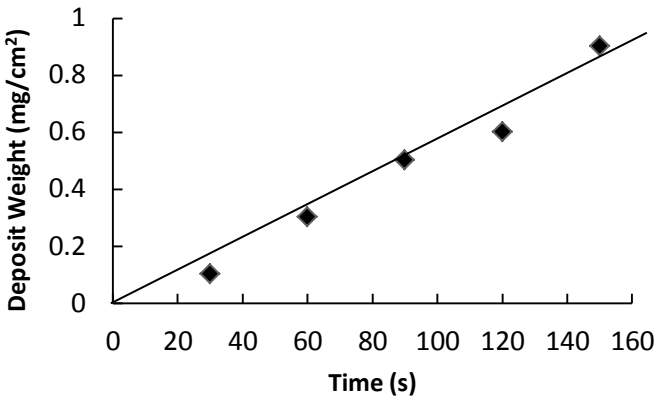

Figure 1: Deposit density vs time for cobalt ferrite nanoparticles deposited on an aluminum substrate.

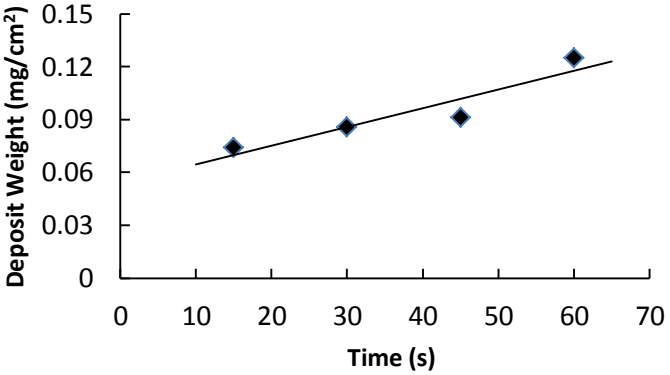

Figure 2: Deposit density vs time for platinum cobalt nanoparticles deposited on an aluminum substrate.

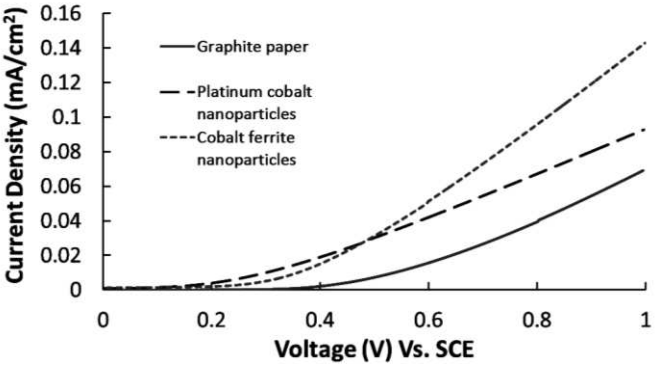

Figure 3: Current density vs applied potential of nanoparticles deposited on graphite paper in 2M ammonia sulfite.

References

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2. Z. Zi, Y. Sun, X. Zhu, Z. Yang, J. Dai, and W. Song. J. Mag. and Mag. Mat., **321(9)**, 1251 (2009).

Acknowledgments

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